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EXCELENCIA SEVERO OCHOA

Mineral dust modeling for optimizing operation and maintenance procedures in concentrated solar power plants

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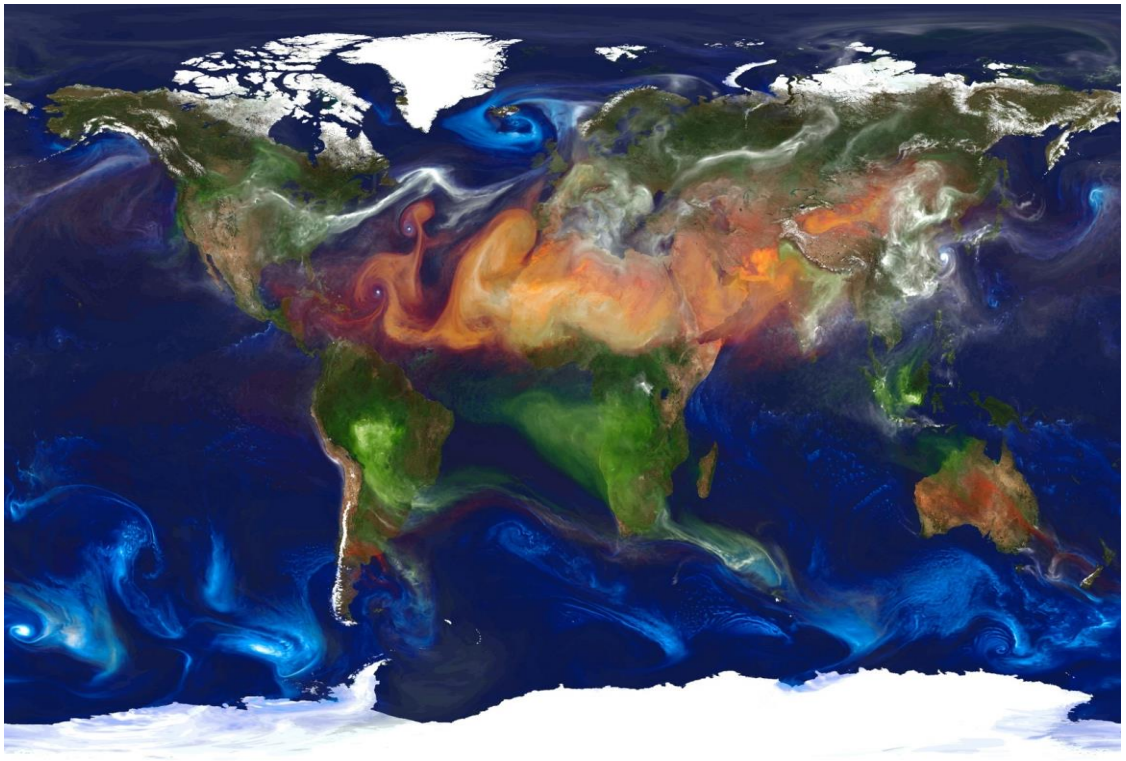
EMS conference, Lungby, Denmark

11/09/2019

Dust cycle, its extension and impacts



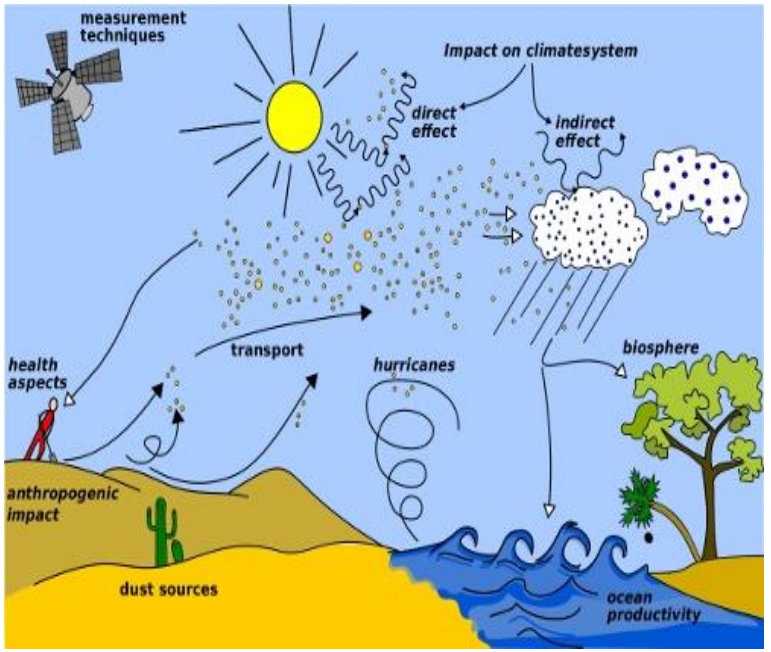


Image from WMO website (http://www.wmo.int/pages/prog/arep/wwrp/new/hurricanes.html)

NASA | GEOS-5 Aerosols

Organic Carbon + Elemental carbon
Dust
Sulfate
Sea salt

Ecosystems, meteorology and climate
Air Quality and Human Health
Aviation and Ground Transportation
Energy and industry
Agriculture and fishering
Astrophysics

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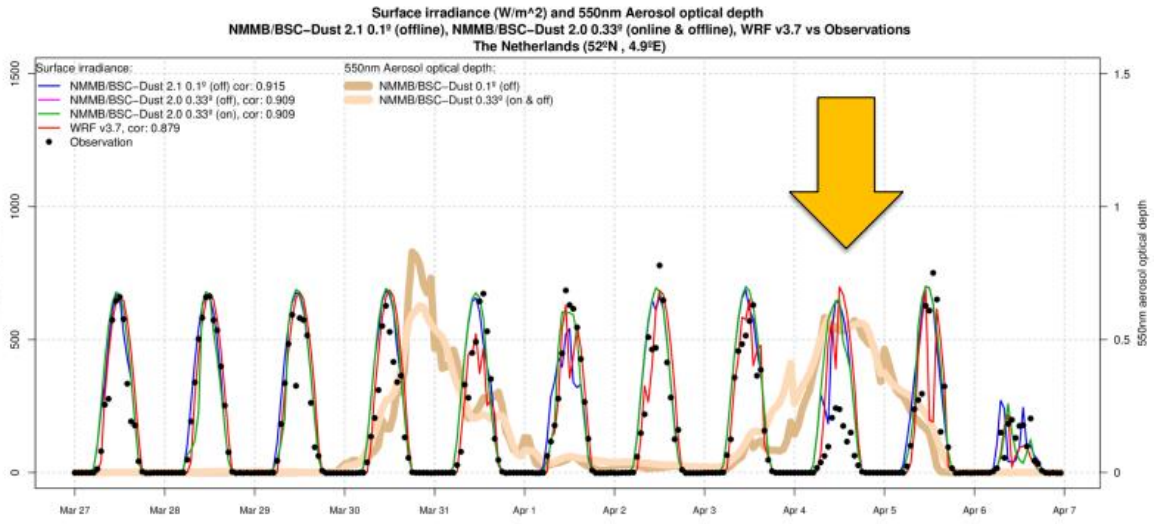
Dust impacts on Solar energy

- Solar irradiance
  - The presence of dust reduce the incoming solar irradiance through direct radiative effect
  - but also indirectly, through favouring cloud formation



(Soret et al., 2016)

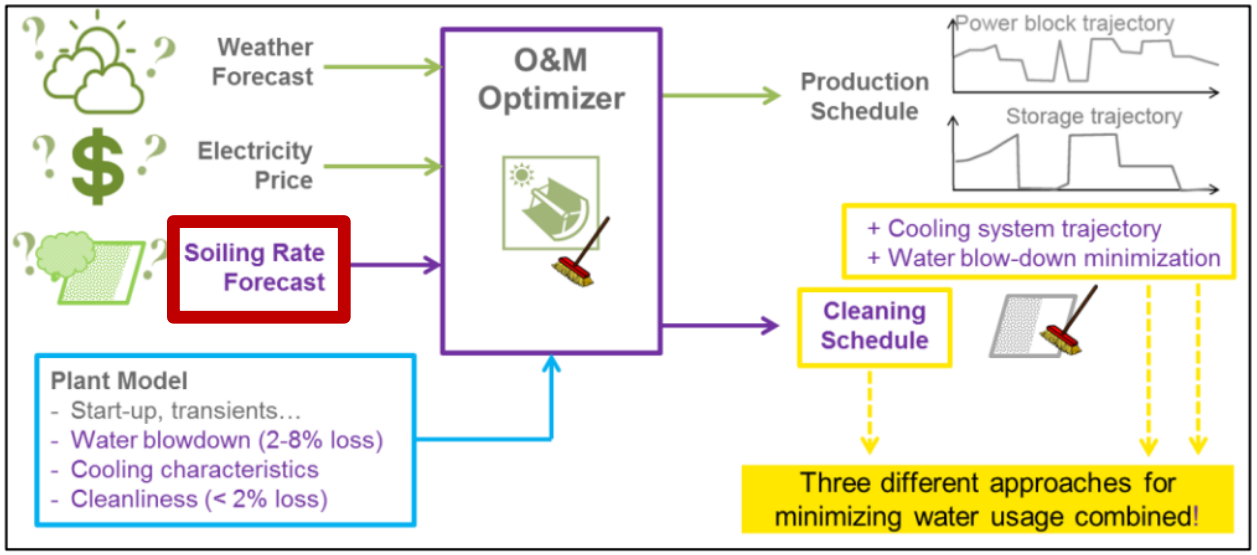
- Soiling
  - panels efficiency and water management

SOLWARIS project

Provide near to market solutions for reducing the water consumption of CSP

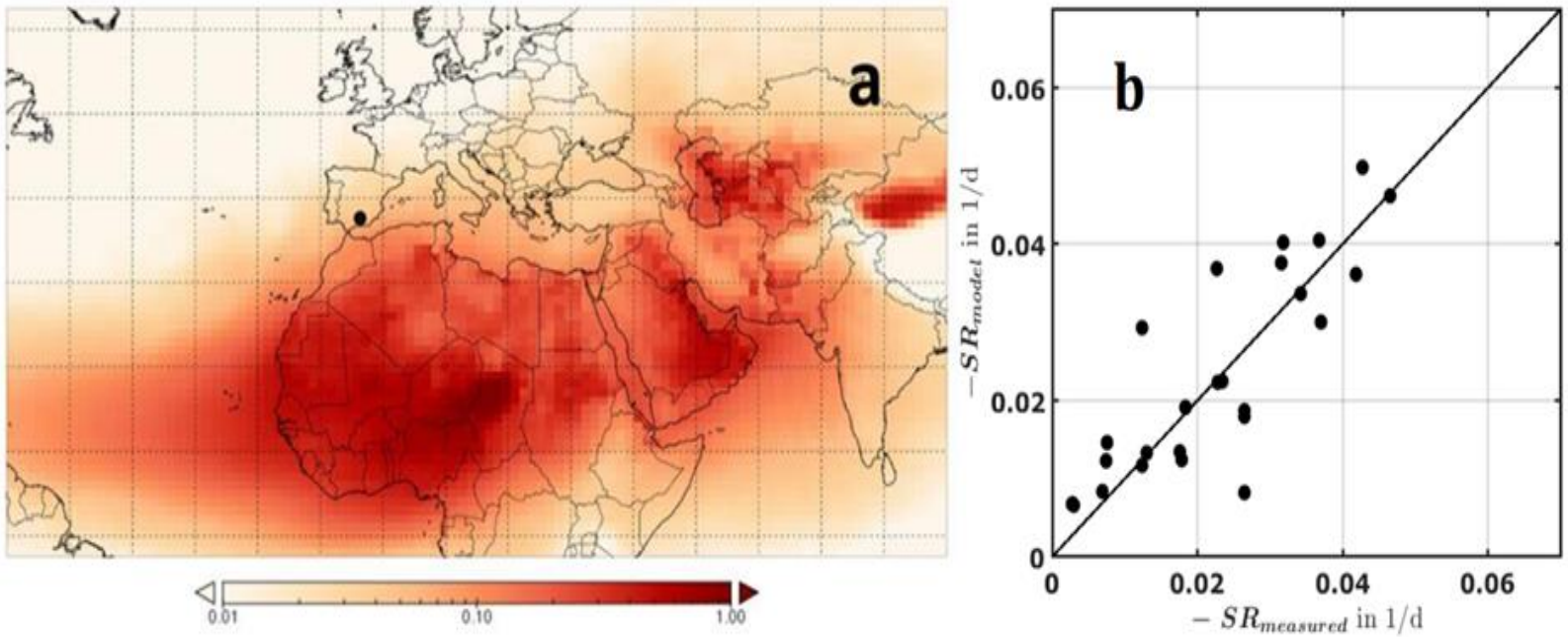
H2020 SOLWARIS project targets a significant reduction in the water used by CSP plants (by 35% for wet cooled & by 90% for dry cooled). In this way more of 0.5 M€/year of operational cost for a 50 MW CSP plant will be saved in the future.

→ O&M optimizer supported by soiling forecasts assures that innovative water-saving technologies are used in the best way.



Objective: to deploy a soiling forecast!

Merge of dust-soiling model

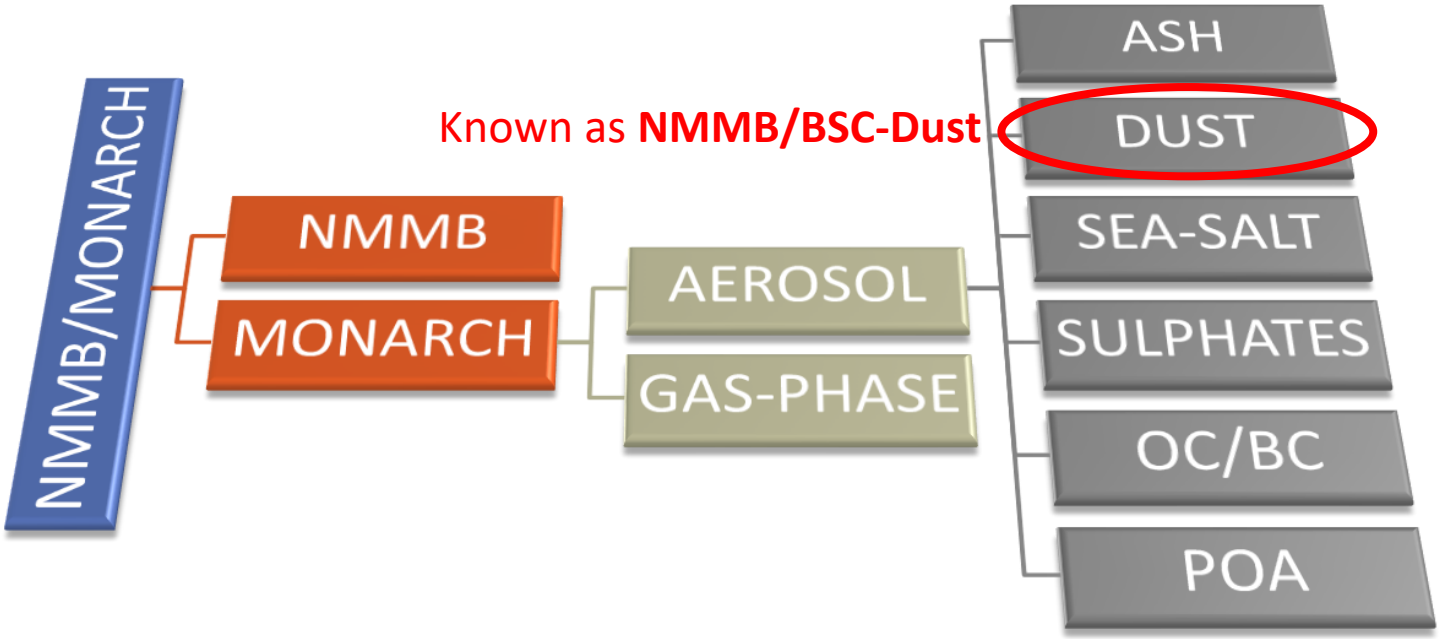


(Wolfertstetter et al., 2018)

- The DLR Institute of Solar Research (SF) is the largest research entity in Germany investigating and developing concentrating solar technologies to provide heat, electricity and fuel.
- DLR has developed a soiling model that has been validated for two sites during WASCOP –Water Saving for Concentrated Solar Power (H2020 project).

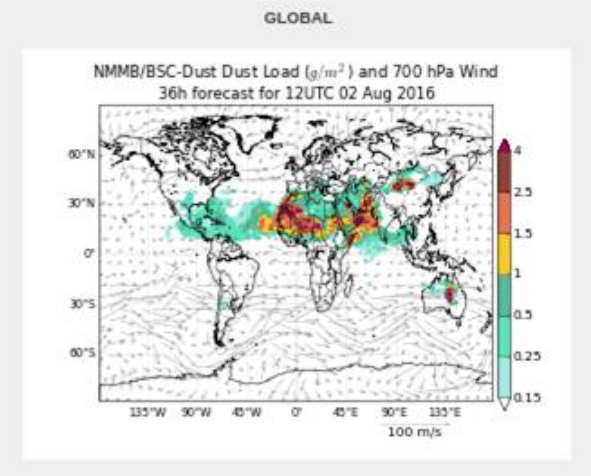
NMMB-MONARCH:
Atmospheric Composition and Air Quality

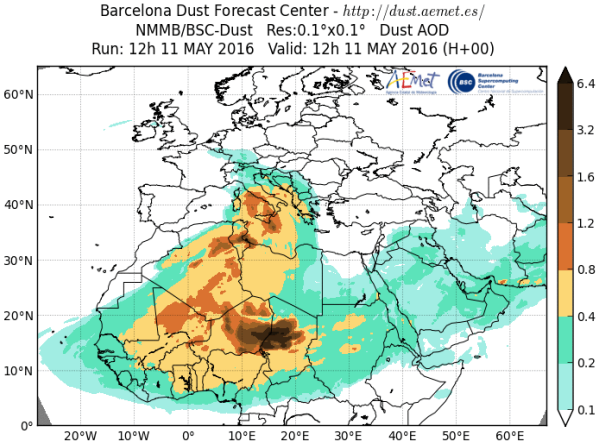
· The main system is build on the **meteorological driver NMMB**
· ***Multiscale***: global to regional scales allowed (nesting capabilities)
· ***Nonhydrostatic*** dynamical core: single digit kilometre resolution allowed
· Fully ***on-line*** coupling: weather-chemistry feedback processes allowed
· Enhancement with a ***data assimilation*** system



Mineral Dust Services

- **BSC dust operational forecast** (global and regional domains)
  - Contribution to the SDS-WAS (regional, 3-days forescast) and ICAP (global, 5-days forecasts) multi-model ensembles
- **WMO Dust Regional Centers**
  - **Barcelona Dust Forecast Center.** First specialized WMO Center for mineral dust prediction. Started in 2014 - Operational
    - *http://dust.aemet.es*
    - *@Dust_Barcelona*
  - **SDS-WAS Regional Center**. Sand and Dust Storm Warning Advisory and Assessment System. Started in 2010 – Research
    - *http://sds-was.aemet.es*





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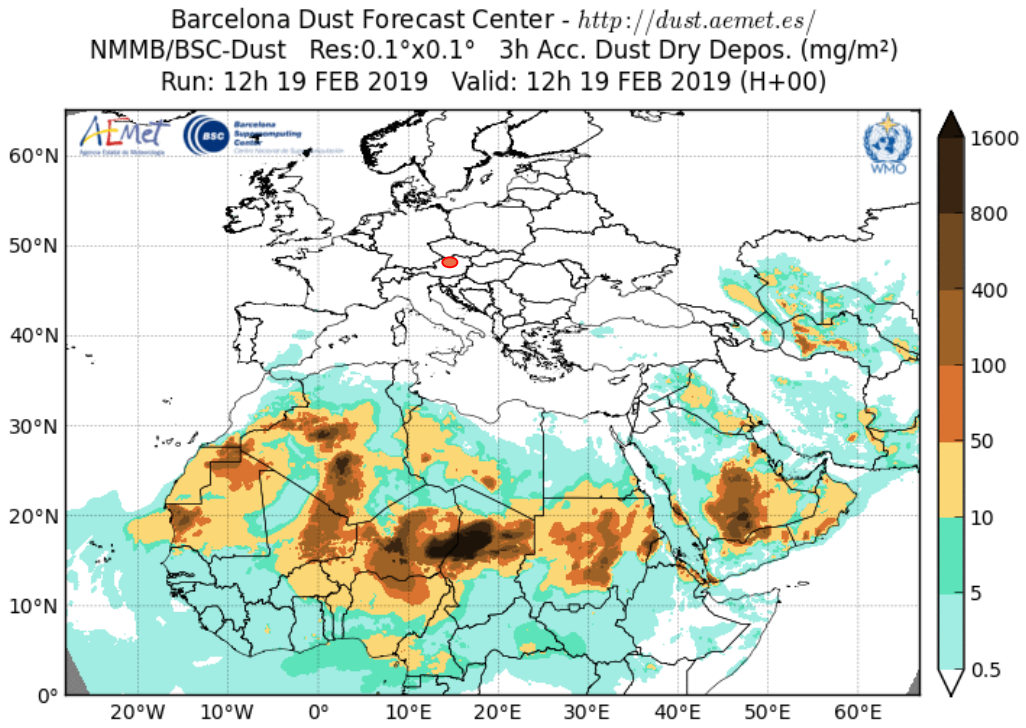
GOBIERNO DE ESPAÑA
MINISTERIO DE AGRICULTURA, ALIMENTACIÓN Y MEDIO AMBIENTE

AEMet
Agencia Estatal de Meteorología

Soiling-Downscaling

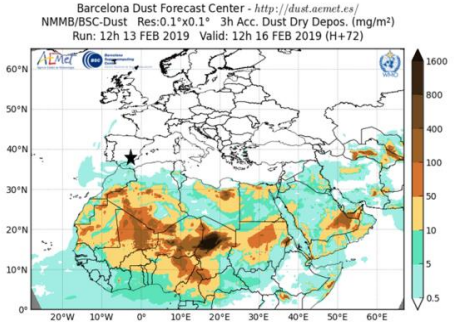


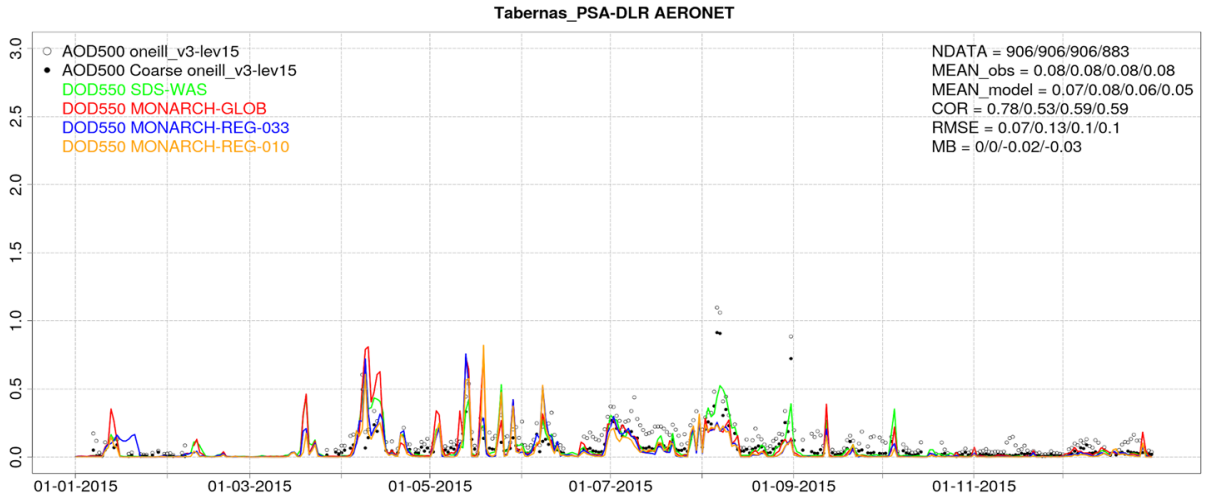
Operational regional dust forecasts MONARCH

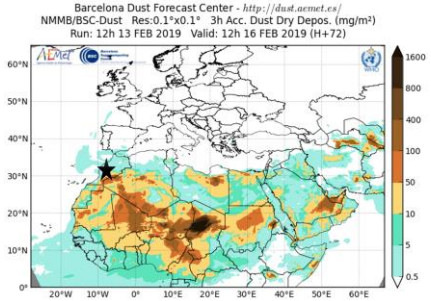
Biggest solar plant in EU in Hungary is 300,000m^2 → This is 0,3km2 vs 100km^2 from the model

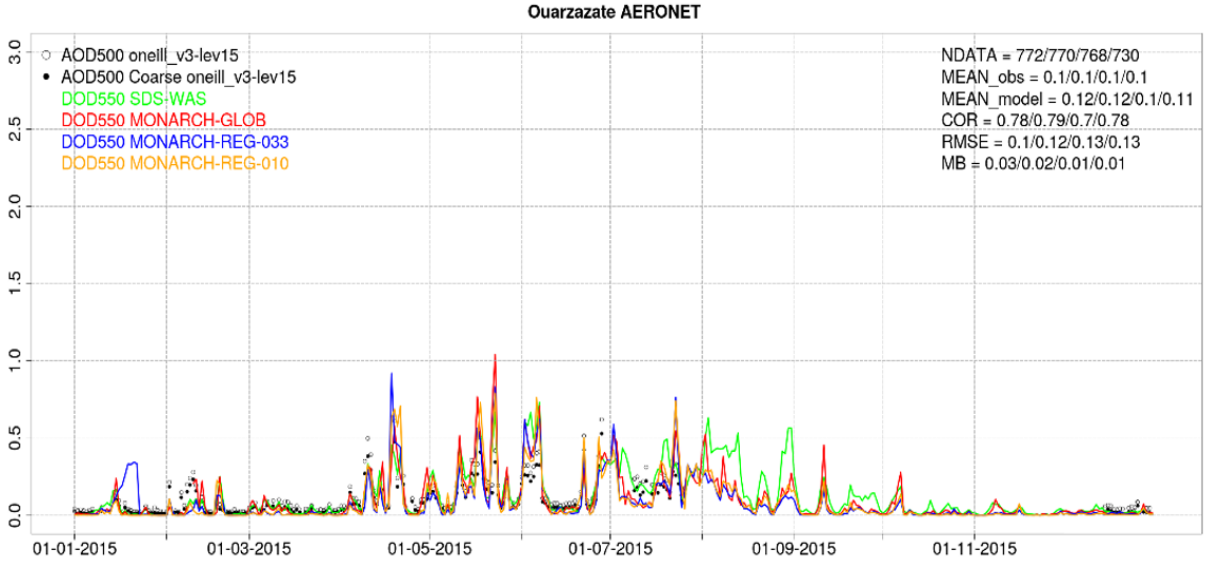
Prediction over specific locations DLR soiling model

Dust: Model evaluation results 2015

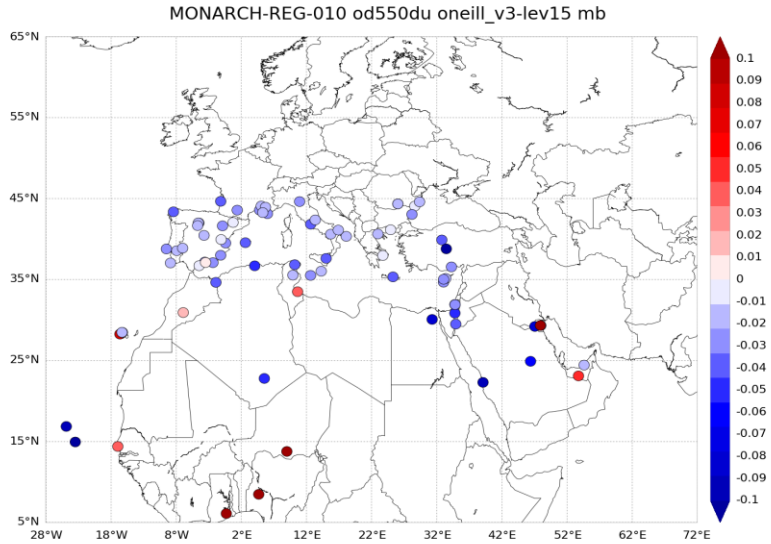


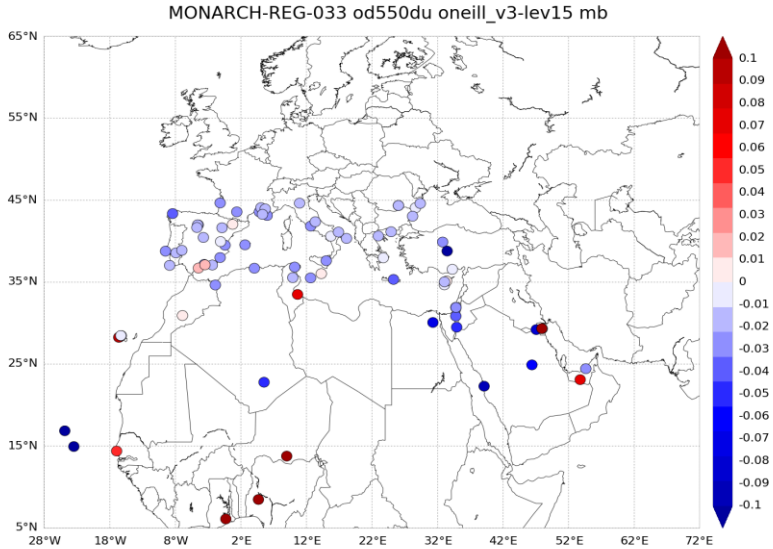


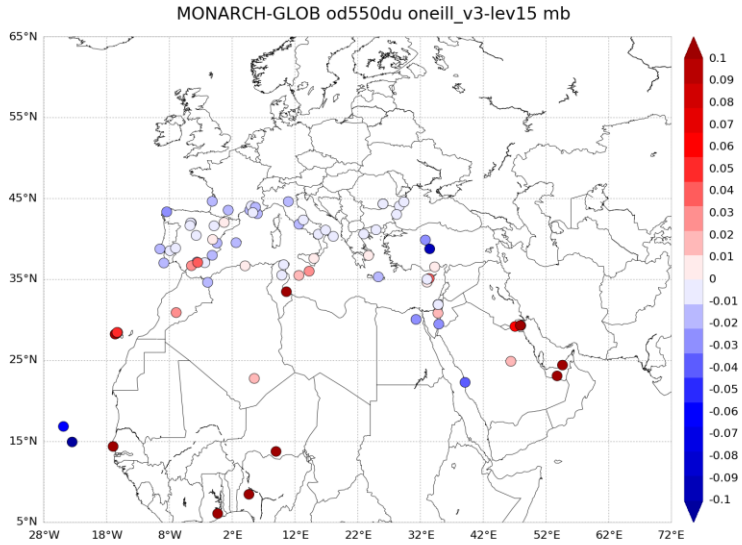


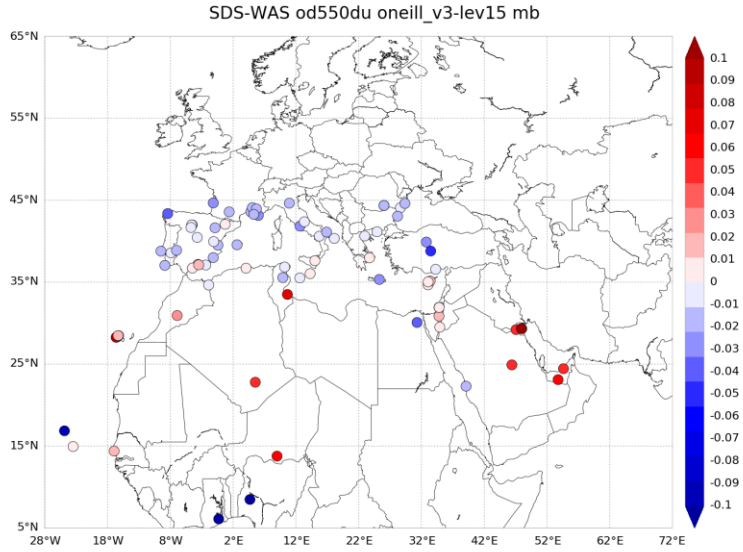


Dust AOD Evaluation: AERONET in-situ 2015

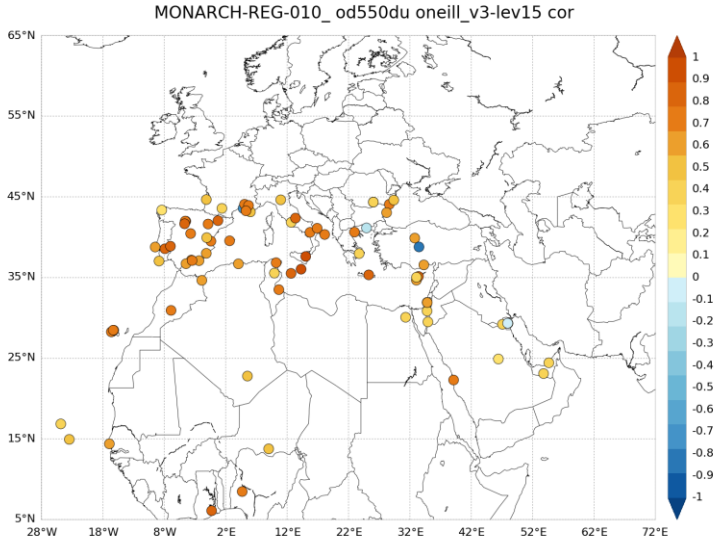


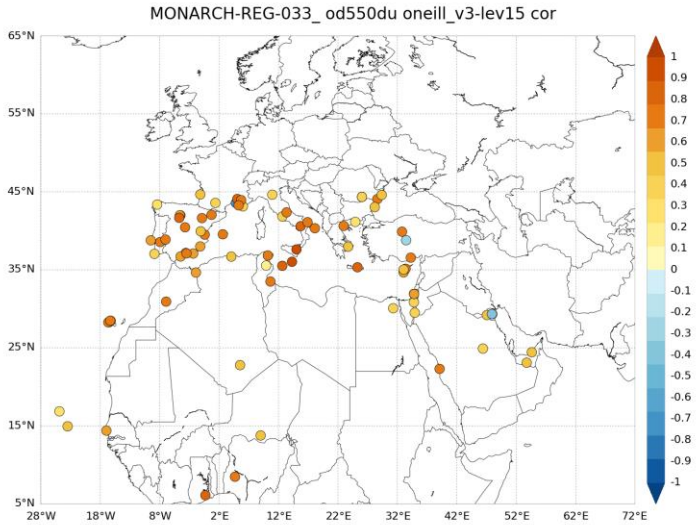


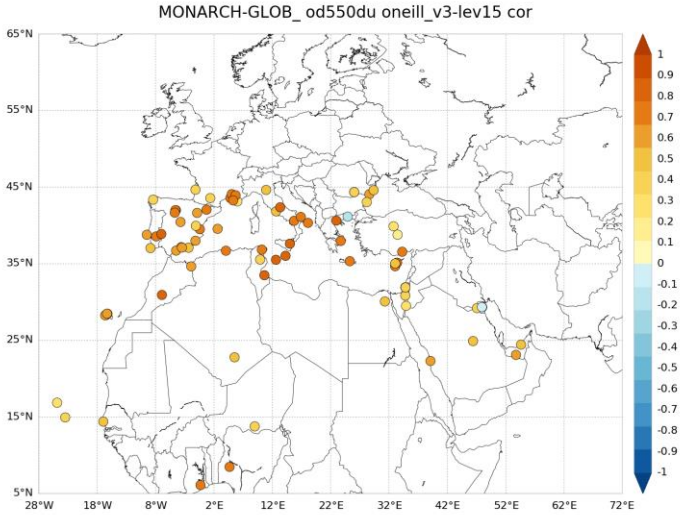


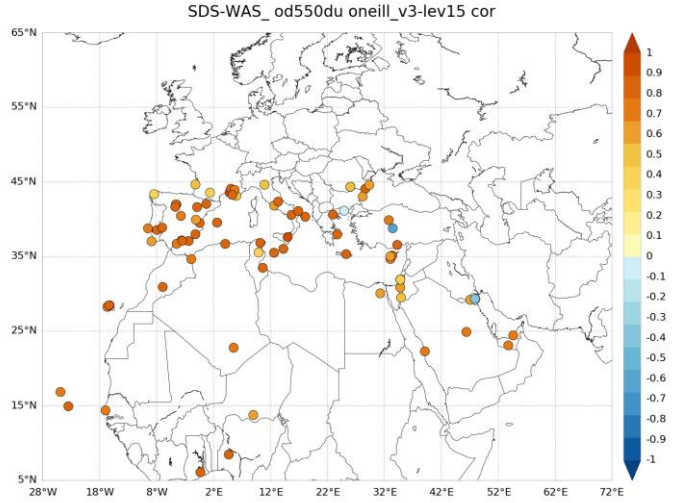


Dust AOD Evaluation: AERONET in-situ 2015



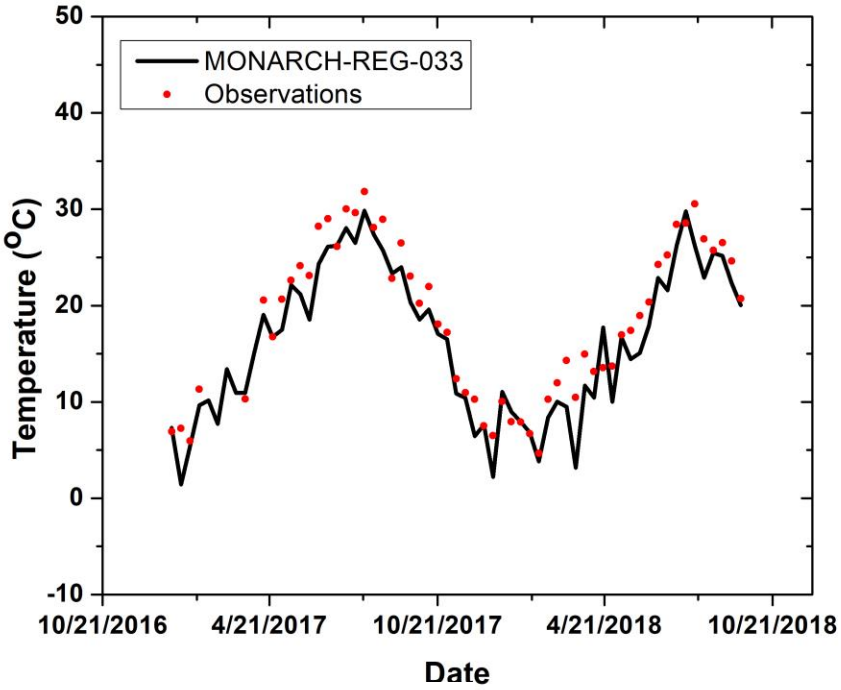


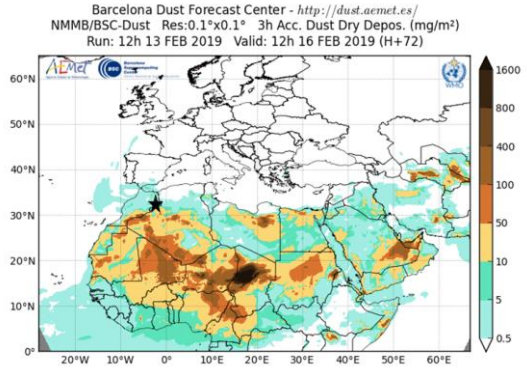




Meteo: Model evaluation results for temperature for the years for 2017-2018

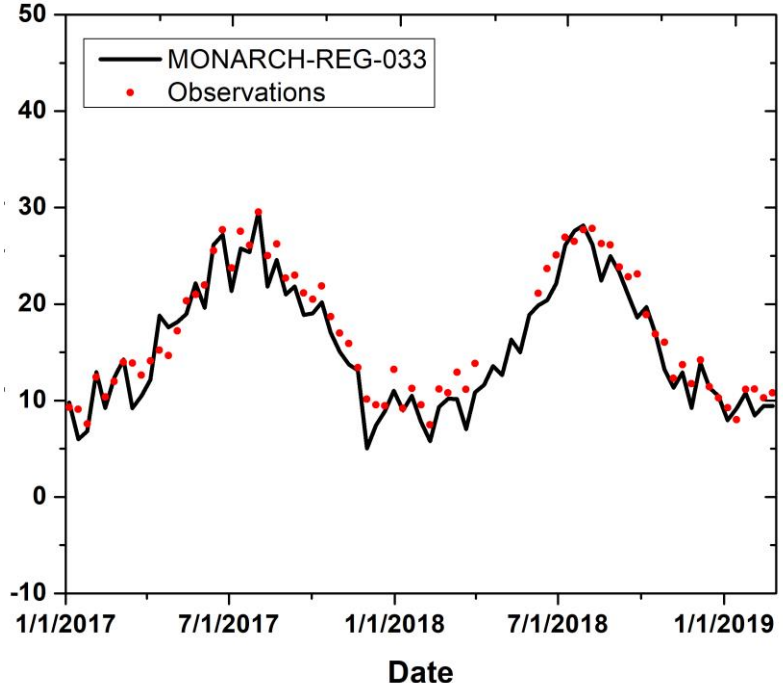
Missour, Morocco

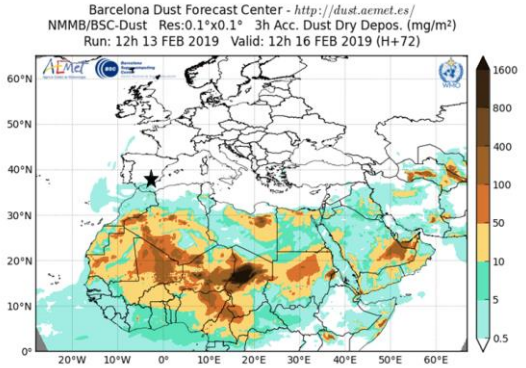




T_{BSC}= 16.3 °C
T_{DLR}= 18.5 °C
MB= 1.9
COR= 0.97
RMSE=2.6

Tabernas, Spain

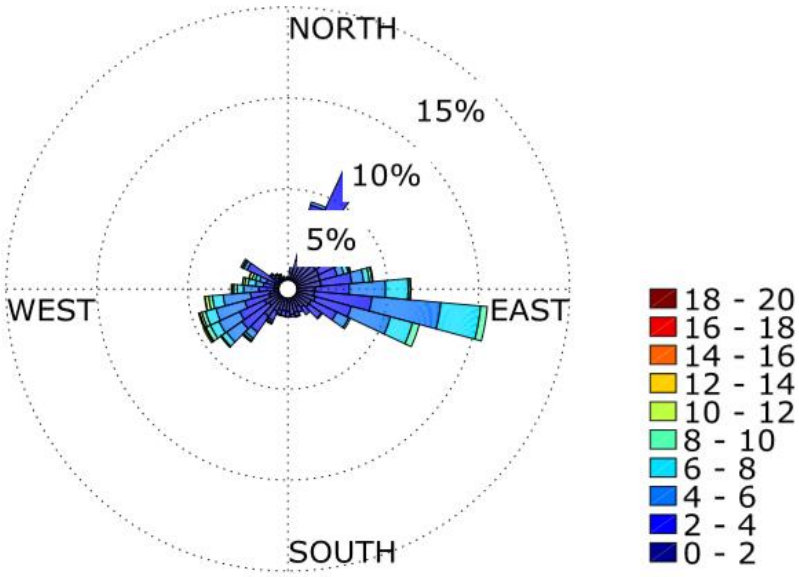




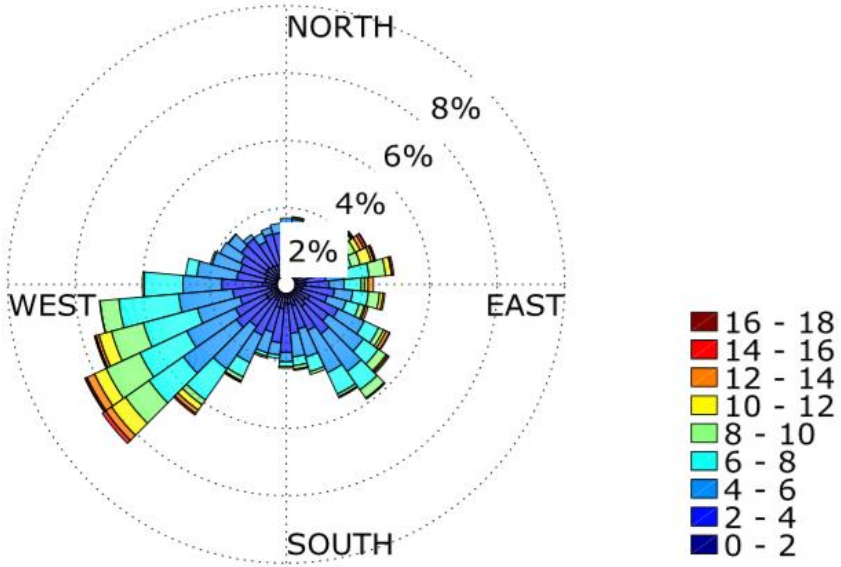
T_{BSC}= 15.6 °C
T_{DLR}= 16.9 °C
MB= 1.5
COR= 0.97
RMSE=1.9

Meteo: Model evaluation results for wind rose for the years 2017-2018

Tabernas, Spain



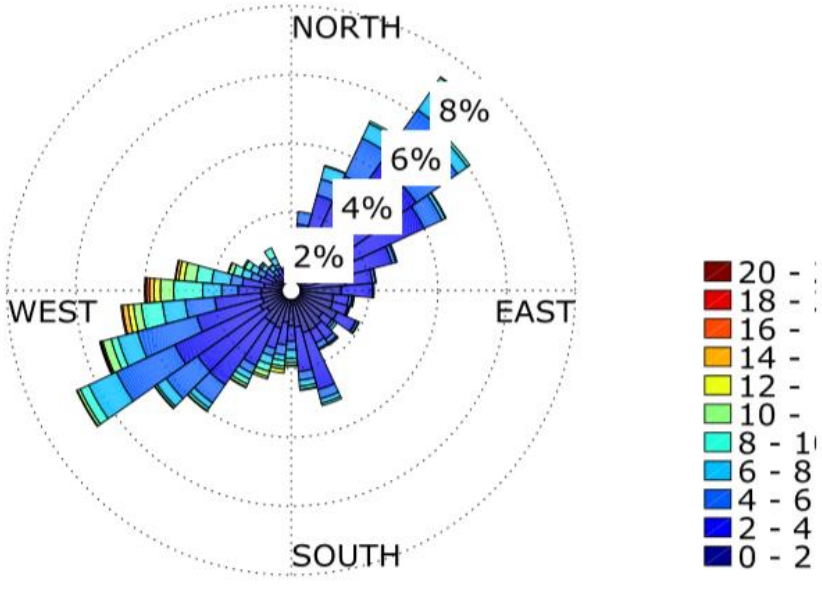
Observations

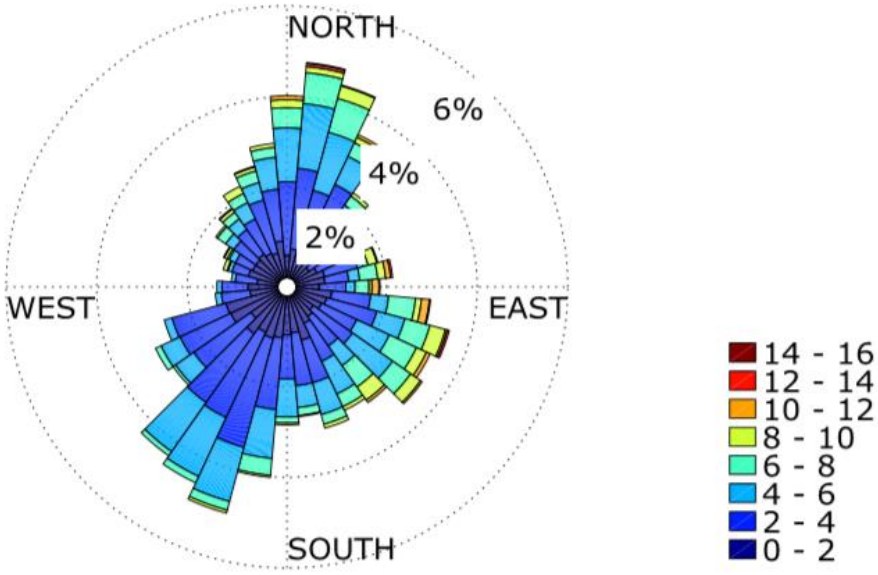


MONARCH-REG-033

Meteo: Model evaluation results for wind rose for the years 2017-2018

Missour, Morocco



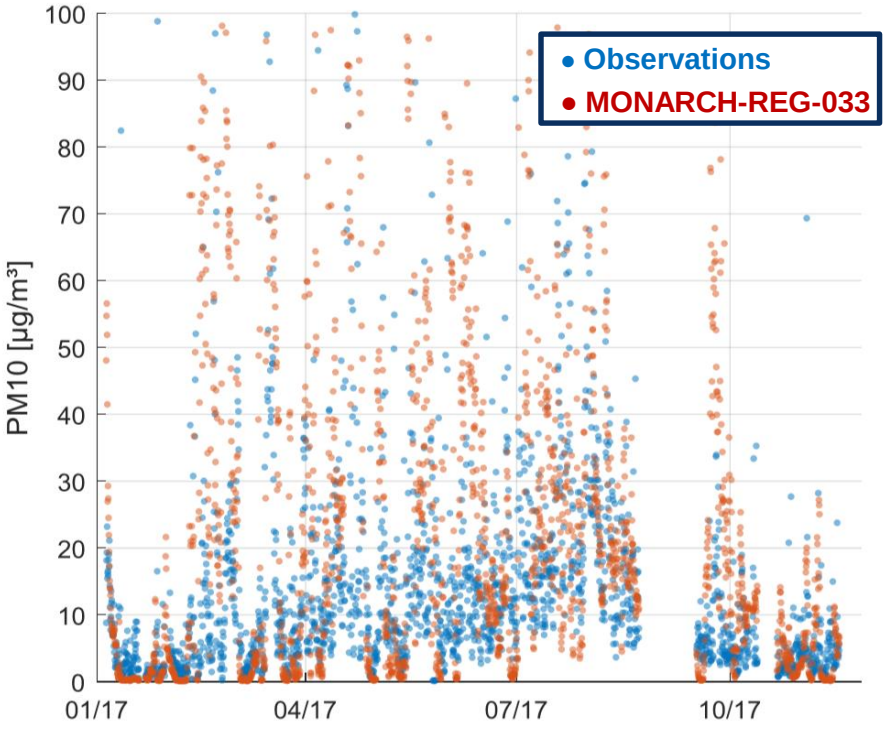


Observations

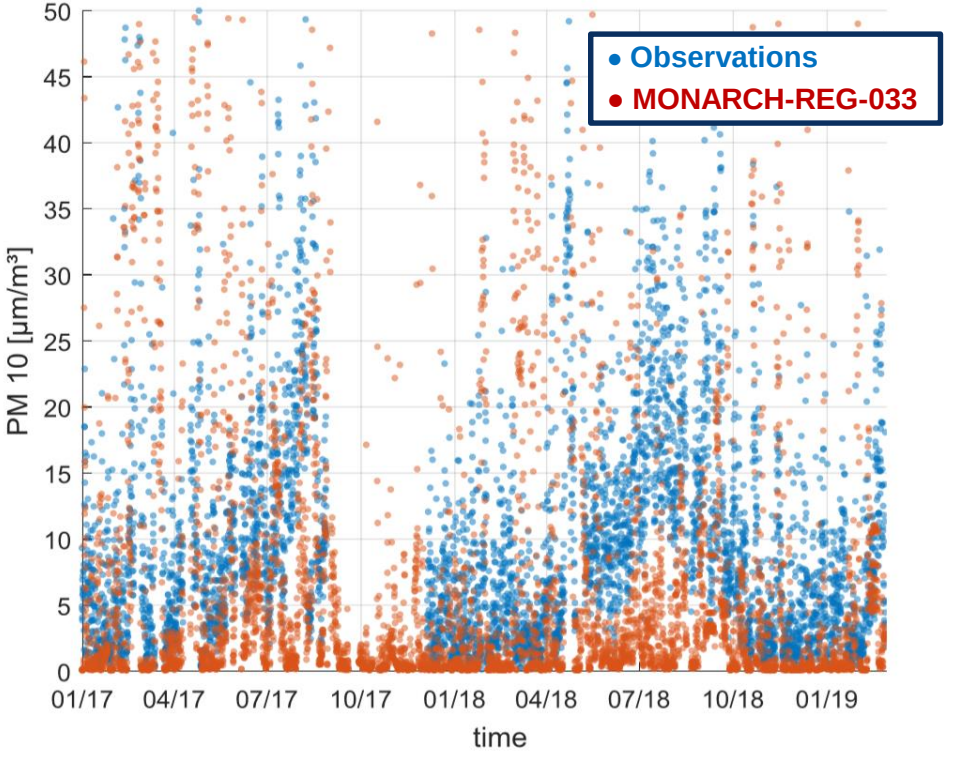
MONARCH-REG-033

Model evaluation results for PM_{10} for the years 2017-2018

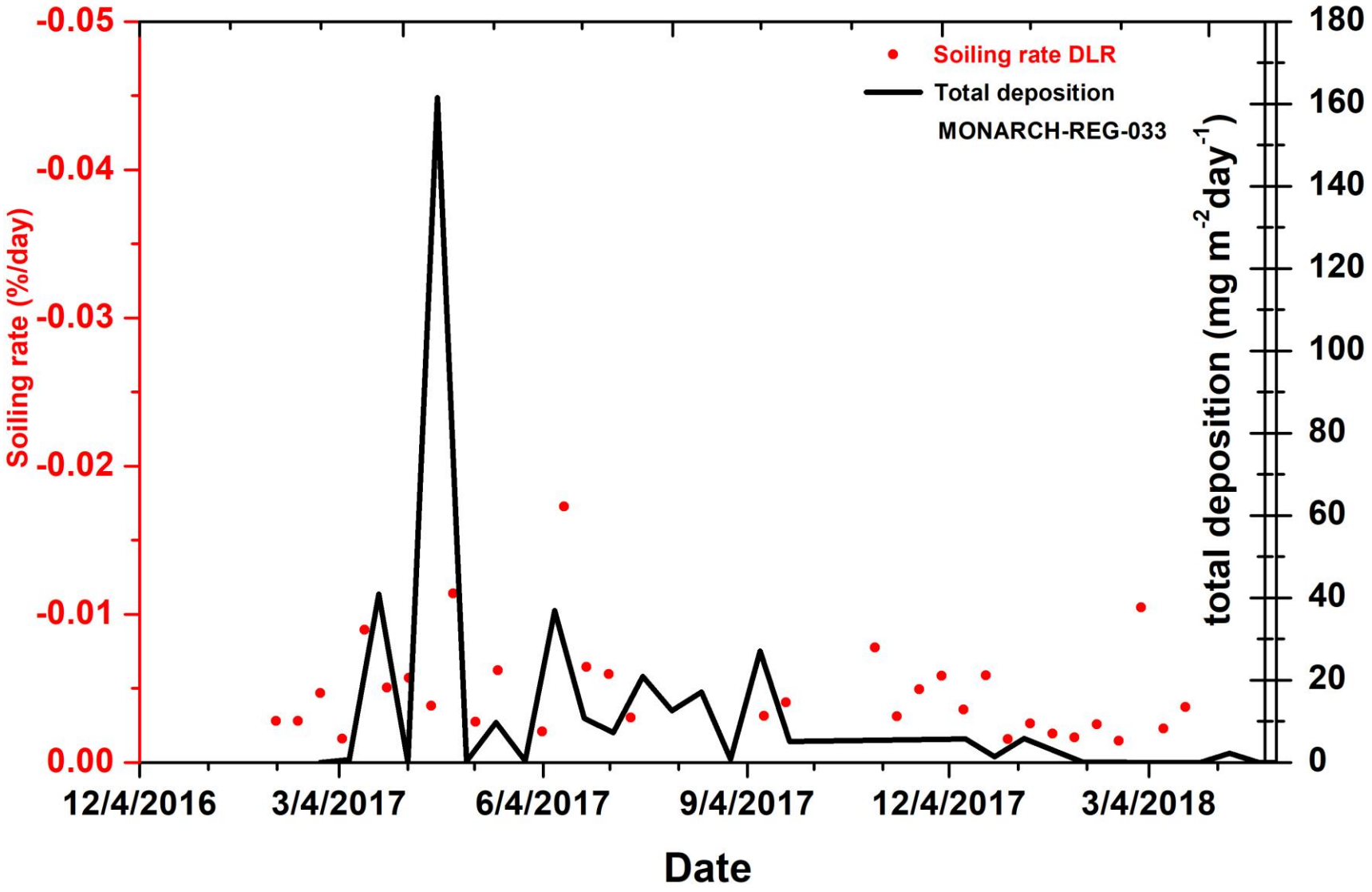
Missour, Morocco



Tabernas, Spain

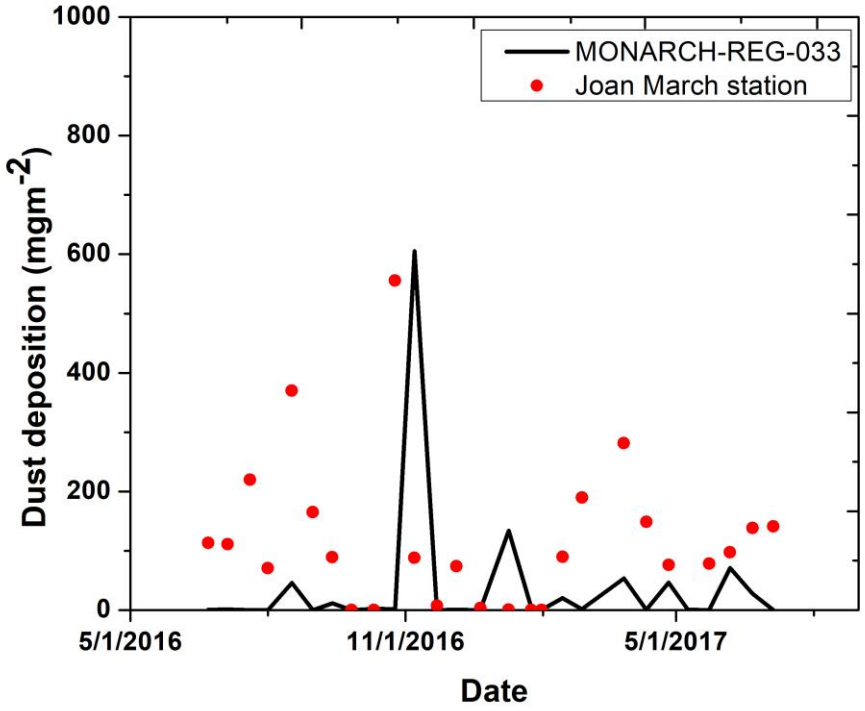


Soiling rate vs total dust deposition

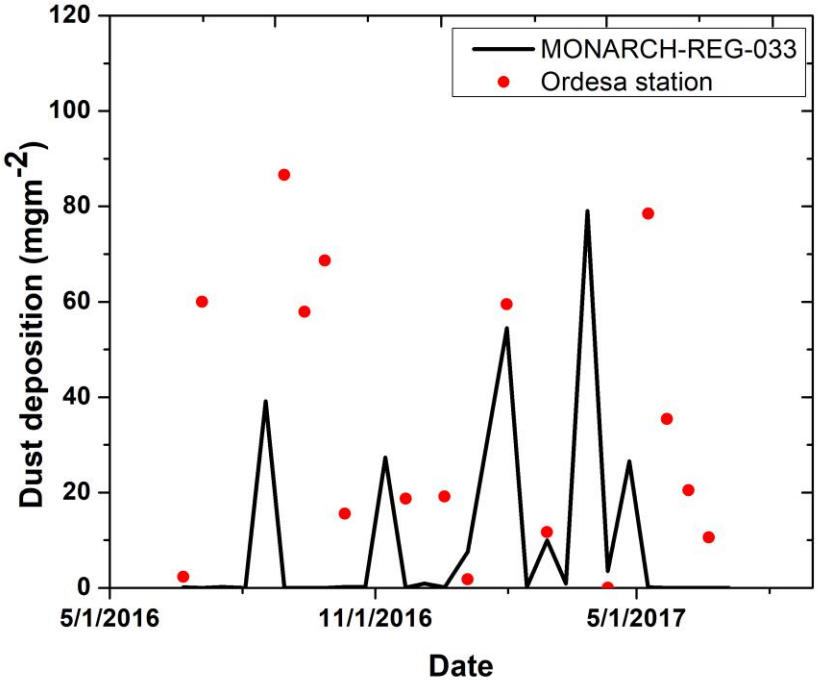


Model evaluation results for deposition data over Iberian Peninsula, preliminary

Joan March



Ordesa



From Jorge Pey, CSIC, Instituto Pirenaico de Ecología

Summary

- Within H2020 SOLWARIS we will provide **operational soiling forecasts**.
- To achieve this objective, the dust atmospheric NMMB-MONARCH model will be coupled with a soiling model.
  - The evaluation of NMMB-MONARCH (the inputs used by the soiling model) shows that the model can predict the desert dust cycle over North Africa, Middle East and Europe.
    - Over southern Spain and Morocco, where is focusing the project, the model is capturing the timing and the magnitude of the dust events.
      - The 3 experiments considered (from 100 to 10km) have similar skills scores in the dust comparison with AERONET for long-range transport regions.
      - The meteorology is relatively well captured by the model. Model underestimates <2K (in absolute error) in annual basis.
      - For wind, it can predict the main wind pattern although overestimates wind speed. This can be linked to the spatial representation of the sites considered and the resolution of the model evaluated.
      - For the PM10 comparisons, in those periods where the model is underestimating the observations in Tabernas (particularly in summer months), ongoing work for characterising the aerosol in this site (local sources vs regional transport). Better results are found in Missour.
      - For soiling we are comparing only-dust model simulations against full-aerosols observations. Ongoing analysis is focusing only on African days.
  - Next steps: Deposition evaluation on 14 station in Iberian Peninsula is ongoing, impact of the resolution on the model results (downscaling to <5km), contribution of other relevant aerosols.

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AXA Research Fund

cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

inDust
COST Action CA15202

SOLWATT

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Thank you

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